Adapting Atlantic Canadian Fisheries to Climate Change

This working document has been created to incite the fishing community to discuss and exchange information on how climate change may impact the industry and how some, such as the Gulf NS Fishermen’s Coalition, are adapting to this change. It has been developed in the context of an Ecology Action Centre Climate Change Adaptation Project in Cheticamp, Cape Breton. Please contribute to the discussion on our blog at: www.climatefishblog.com.

Recent Trends in the Fishery

In Atlantic Canada, commercial fishery landings in 2011 were half of those in 1990. However, the value of landings in 2011 was 1.6 times that of 1990. Groundfish stocks collapsed in the early 1990s, while pelagic and estuarial fish (mackerel, herring, gaspereau, eels, tuna, etc.) catches have also dropped from almost 3 million lbs in 1990 to ½ million in 2011. Lobster catches in the Atlantic region have increased from 105 million lbs in 1990 to 146 million lbs in 2011.

Fishermen in Atlantic Canada have always adapted their fishing to changes in fish stocks. Until the early 1990s, groundfish was an important fishery. After its collapse, fishing effort increased in lobster, shrimp, and crab. Though the value of landings in Nova Scotia increased in the mid- to late 90s, the number of people employed in the fisheries decreased. Since 2003, the fishing industry has been challenged by declining revenues and a decrease in crew due to youth out-migration.

Climate change is expected to increase stress on fisheries resources. Some stressors are directly associated with climate change, while others are increasing the vulnerability of the industry to climate change, reducing its adaptive capacity.

![Figure 1](https://example.com/figure1.png)  
*Figure 1. Total fisheries landings from 1985 to 2011 in Statistical District 2 (from Margaree to Pleasant Bay). Note: some years are skipped.*
The story of cod:
There is no doubt that overfishing by the mobile fleet contributed to the collapse of the cod stocks in the early 1990s. However, temperature is also a contributing factor to stock health. In the Northern Gulf of St. Lawrence, cold water in the early 90s decreased cod health, increased natural mortality and slowed recovery after the moratorium was imposed\textsuperscript{10}. Further south, from North Carolina to the Gulf of Maine, increasing surface water temperatures over the last 40 years have caused 36 fish stocks, including cod, to shift northwards\textsuperscript{11}.

The story of mackerel:
Mackerel are a good indicator of sea surface temperature. Mackerel overwinter on the margins of the Continental Shelf in deeper, warmer waters and migrate into the Gulf of St. Lawrence during spring. As temperatures increase, larger mackerel have been migrating further north to Quebec and Newfoundland, and perhaps as far as Iceland. Spring and winter migration timing is also shifting—mackerel move into the Gulf later and stay longer\textsuperscript{12}.

The story of lobster:

Maine: For the past dozen years, temperatures in the Gulf of Maine have been rising. During the first six months of 2012, surface temperatures in the area were the highest ever recorded and bottom temperatures were also above average\textsuperscript{11}. Fishermen observed lobsters molting as much as 4 to 6 weeks earlier than other years\textsuperscript{13}. Catches were record high, but wharf prices for soft shelled lobster were as low as $2 per pound, the lowest in 30-years\textsuperscript{14}.

Southern New England: Lobsters avoid water warmer than 19°C, and prolonged exposure to water above 20°C causes increased incidence of shell disease, increased acidity in body fluids, respiratory stress and suppression of lobsters’ immune defenses\textsuperscript{15}. Since 1999, a widespread increase in the area and duration of water temperatures above 20°C in Southern New England means that lobster stocks are not likely to rebuild.
2. REDUCED SALINITY:
Coastal waters are becoming less saline due to melting sea ice and more rainfall in high latitudes.

**POTENTIAL EFFECTS:**
» Increased water stratification— with a warmer, fresher upper surface and saltier, colder deep layer – and less mixing of those layers. Normally, spring phytoplankton growth relies on winter winds and cooling to mix layers, bringing oxygen to deep water and nutrients to the surface.

3. DECREASE IN OXYGEN (HYPOXIA):
Warmer water holds less oxygen. In coastal water, oxygen is declining at a faster rate than in the open ocean (>100km offshore) due to increased organic material (from land-based run-off). In deeper waters, hypoxia is caused by increased stratification and lack of mixing with surface water, which contains more oxygen\textsuperscript{10,7}.

**POTENTIAL EFFECTS:**
» Mortality in extreme hypoxia.
» Reduced feeding, growth rate, and activity (such as predator avoidance) in mild hypoxia.
» A negative effect on deepwater species such as deepwater and Acadian redfish or if a species is close to their tolerance limit in certain severely hypoxic areas (e.g. Greenland halibut, northern shrimp)\textsuperscript{8}.

**Hypoxia sensitive species:** Crustaceans (including lobster, rock crab and sand shrimp) and fish.

**Hypoxia tolerant species:** Mollusks (blue mussel, soft-shell clam, etc.), polychaetes (worms), echinoderms (sea stars, sea urchins, etc.), jellyfish, and possibly, snow crab.

4. INCREASED ACIDITY:
As CO\textsubscript{2} increases in the atmosphere, it also increases in the ocean, through gas exchange. Ocean acidification occurs as a portion of the increased CO\textsubscript{2} reacts with seawater to form carbonic acid, increasing hydrogen ion concentration. As the chemistry of seawater is altered, this affects the nutrients, trace elements and toxins available to marine organisms; particularly carbonate, an essential component in shell formation. Because calcium carbonate and CO\textsubscript{2} are more soluble at low temperatures, acidification is expected to be felt first at high latitudes and in low-oxygen waters\textsuperscript{15,16}.

**POTENTIAL EFFECTS:**
» Reduced growth and productivity of calcium carbonate-based organisms (crustaceans and mollusks) including lobster, crab, shrimp, sea urchin, scallop, mussel, oyster and clam.
» Impaired respiration in large invertebrates, fish and some zooplankton.
» Impaired reproduction.
» Increased growth of certain seaweeds and sea grass.

The effects of ocean acidification are not yet well understood but are likely to be far-reaching and complex. Experiments suggest that marine organisms respond differently depending on their physiology and habitat. High-CO\textsubscript{2} and low-pH waters may stimulate the growth of toxic phytoplanktons.

**The story of oysters:**
Increasing ocean acidification is linked to the collapse of oyster seed. At a commercial hatchery in Oregon, elevated CO\textsubscript{2} levels resulted in more corrosive seawater and inhibited the larval oysters from developing their shells and growing at a cost-effective pace\textsuperscript{17}. Although this is a local effect, it does provide a glimpse of possible future acidification impacts.
5. LESS SEA ICE AND SNOW COVER:
A 2°C increase in air temperature could result in a loss of up to 28% of ice cover and up to 55% reduction of ice volume. Winter 2010 was warmer than the mean (from 1969 to 2011) by 4.7°C with almost no ice in the Gulf of St. Lawrence. 2011 was warmer by only 1.7°C, still with very low ice cover.

POTENTIAL EFFECTS:
» Increased rates of coastal erosion.
» Increased time spent in the Gulf by seasonally resident whales.
» Harp seals moving north or declining with lack of sea ice (expected to negatively impact seal hunting industry).
» Grey seals expanding distribution (expected to negatively affect the fishery).

6. RISING SEA LEVEL AND STORM SURGES:
Sea levels will rise due to thermal expansion of the oceans, melting of non-polar glaciers and decreasing ice sheets. Sea level, as measured in Charlottetown, has risen by 32 cm since 1900 due to subsiding land. Storm surges have increased in frequency in Atlantic Canada over the past ten years, causing extreme flooding events.

POTENTIAL EFFECTS (in Cheticamp area):
» Sea level rising by 45 cm in 2055 and 1.1 m by 2100 (from 2000 levels).
» Storm surges levels rising by 45 cm by 2055, and 1.1 m by 2100.
» “1-in-100-year storm events” occurring more than once every 10 years by 2055.

COSTS OF FISHING:
The cost of fishing has been steadily increasing, whereas the price of lobster has decreased. Costs of investing in a license, boat and gear have rapidly risen beyond the capacity of many potential new entrants – in some areas, costs have more than doubled since the 1990s. Costs are projected to increase with the price of gas- not only affecting the cost of fuel for fishing but also bait and equipment that require shipping. Long-haul transportation costs and holding or conserving freshness (as temperatures increase) will also affect the prices fishermen get for their product. The costs of maintaining product quality and for product loss (due to heat stress) will further impact wharf prices.

LACK OF BAIT:
Bait, consisting of mackerel, herring, gaspereau, capelin and sea perch, was traditionally caught as needed during the fishing season. In the last four years, however, no bait was locally available. Mackerel arrives later in the summer, no longer coinciding with the spring lobster and snow crab fisheries, gaspereau has decreased due to changes in rivers and brooks, and herring has become rare. Fishermen now rely on bait purchased from other regions. In 1997, bait cost $12/lb for herring, while in 2012, Cheticamp lobster fishermen paid $95/lb for frozen mackerel from Japan. Increasing transportation and refrigeration costs are also likely to inflate bait prices.
MONITORING CHANGE

Climate change will cause many changes for fisheries in Atlantic Canada. Although scientific projections and experiences from other regions help provide a sense of what to expect, many questions remain. Although the effects of some factors on certain life stages of species are understood, the combination of multiple effects is too complex to predict with certainty. Yet, there is no doubt that climate change related impacts will affect reproduction, migration, early life stages, development, growth rates and movement, not to mention the food web and other species interactions.

ADAPTING TO CHANGE

There is no going back - with nations doing little to slow climate change, many people are ramping up plans to adapt. Just as they have adapted to market and stock changes in the past, the fishing industry will have to do the same for climate change. Planned adaption will result in less stress to our coastal communities than adaptation after the fact. Inshore fishermen need to develop a strategy to increase control over their resource, while maintaining their independence and competitiveness.

For adaptive strategies refer to Table 1 on Page 6.

CONCLUSION

Although climate change will continue to create challenges for the fishing industry in Atlantic Canada, many fisheries may also benefit in the future as a result of climate change. The productivity of several species will be enhanced due to a longer growing season, temperatures closer to optimal temperature for growth, decreased mortality, and possibly enhanced primary productivity (e.g. haddock, cod, herring, mackerel, adult halibut, northern shrimp, capelin and shallow-habitat lobster). However, these effects could be offset by other factors such as acidification, decreased oxygen, and shifts in seasonal patterns.

ACTIONS:

TAKE NOTE OF CHANGES

Keep track of new species, catch variations (in particular changes in the ratio of species in a multi-species fishery), timing of events, weather patterns, etc. Exchange and record information with others.

ADOPT A CONSERVATIONIST APPROACH

Conservation of resources is the best way to ensure their survival. A stressed or overfished population will be much more vulnerable to climate stressors.

REPORT INVASIVE SPECIES

In the Gulf region, contact Renée Bernier at 1.866.759.6600 or 506.851.6636; in the Maritime Region contact Benedikte Vercaemer at 902.426.6733 or Dawn Sephton at 902.426.1865.
### Table 1.

<table>
<thead>
<tr>
<th>CHANGES</th>
<th>EFFECTS</th>
<th>ADAPTIVE MEASURES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GROUNDFISH COLLAPSE</strong></td>
<td>• Decreased employment from fishing</td>
<td>• More effort fishing other species (lobster, snow crab, developing species)</td>
</tr>
<tr>
<td></td>
<td>• Shorter fishing seasons</td>
<td>• Diversifying income sources (tourism, in particular)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Out-migration of the workforce</td>
</tr>
<tr>
<td><strong>TEMPERATURE INCREASE</strong></td>
<td></td>
<td>• Adjustments to fishing seasons</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Conservation measures to reduce effort and increase reproduction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E.g., in the case of lobster:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increase in minimum carapace size for market</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• License and trap reductions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reductions in the number of days of fishing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Careful release of non-commercial catch</td>
</tr>
<tr>
<td><strong>INCREASED OCEAN ACIDIFICATION</strong></td>
<td>• Seasonal changes</td>
<td>• Mitigation of other stressors, such as pollution and destruction of habitat</td>
</tr>
<tr>
<td></td>
<td>• Northward shift of species</td>
<td>• Changing management measures to avoid wasting by-catch</td>
</tr>
<tr>
<td></td>
<td>• Stress on species with calcium carbonate shells (lobster, crab, oysters, clams, and many</td>
<td>• Switch to new species</td>
</tr>
<tr>
<td></td>
<td>prey species</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Stress on all species</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Out-migration of mobile species from areas of low oxygen</td>
<td></td>
</tr>
<tr>
<td><strong>DECLINING OXYGEN LEVEL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SEA LEVEL RISE, INCREASED STORM SURGES, LACK OF SEA ICE COVER</strong></td>
<td>• Port infrastructure damage</td>
<td>• Erosion protection</td>
</tr>
<tr>
<td></td>
<td>• Boat and gear damage</td>
<td>• Stronger construction and higher elevation of wharves/infrastructure</td>
</tr>
<tr>
<td></td>
<td>• Coastal erosion</td>
<td>• Coastal protection and setbacks for construction</td>
</tr>
<tr>
<td></td>
<td>• Silting of harbours</td>
<td>• Diversification of harbour uses to defray increasing harbour maintenance costs,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for instance, as a tourism facility (museum, restaurant, interpretive centre)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Monitoring weather forecasts on a daily basis.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Move gear to deeper water</td>
</tr>
</tbody>
</table>

*Table 1.* Fisheries stressors in Cheticamp, possible effects, and adaptation measures either already taken or under discussion locally or regionally. Information has been compiled from scientific reports, through individual and group discussions with fishermen in Cheticamp and Grand Etang and with the Gulf Nova Scotia Fishermen’s Coalition.
<table>
<thead>
<tr>
<th>Changes cont.</th>
<th>Effects</th>
<th>Adaptive Measures</th>
</tr>
</thead>
</table>
| **Dwindling Bait Supply (Mackerel, Herring, Gaspereau)** | • More expensive imported bait | • Reductions in the amounts used (including trap reductions)  
• Use of fish plant residues  
• Local freezing facilities for storing bait caught out of season  
• Use of non-commercial species or invasive species (such as green crab)  
• Development of artificial bait |
| **Increasing Fuel Prices** | • Increasing costs of fishing, of importing bait, ice and other resources and equipment  
• Decreasing wharf price to offset costs of transportation, refrigeration and holding facilities | Reduction in fuel consumption in fishing by:  
• Decreasing boat speeds  
• Reducing number of traps fished  
• Reductions in fishing days  
• Fishing swings or lines of traps  
• Research more efficient engines and alternative fuels  
• Expand local markets to decrease transportation, refrigeration and holding facilities  
• Use of biofuels and other alternatives |
| **Decreasing Profits** | • Fewer new entrants into the fishery | • Government assistance (NS Fisheries Loan Board)  
• Improved marketing of lobster through the Lobster Council of Canada (funded by industry and government)  
• Consider adopting or adapting a Lobster Apprenticeship Program such as the one in Maine  
• Flexibility for new entrant requirements |
| **Government Cutbacks** | • Cuts to Employment Insurance (EI)  
• Increasing corporate influence on fishery  
• Increasing influence of global forces  
• Closures of DFO licensing offices, staff reductions  
• Changes to fishery management measures  
• Downloading of costs and responsibilities on fishermen  
• Cuts to science | Fishermen’s organizations are presently struggling with the issues of how to:  
• Decrease reliance on EI  
• Modernize the Fisheries Act to ensure adequate protection for fisheries resources and a thriving local independent fishery  
• Provide the support that government is taking away  
• Modernize the fishery licensing policy |
REFERENCES

1. DFO Statistics. 2012. Department of Fisheries and Oceans, Canada.

For more information on climate change adaptation, please visit www.cccheticamp.ca

This project is funded in part by Canada’s Rural Partnership, an initiative of the Government of Canada.